

ALS IR News

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New Grazing Angle Objective Available for BL1.4.3

Zhao Hao and Michael C. Martin, Advanced Light Source

A new Grazing Angle Objective (GAO, [Bruker](#) Optics) is designed to study monolayers or thin films on reflective surfaces, which provides excellent sensitivity, good spatial resolution, and the ability to utilize polarized light. The objective has two modes of operation: visual (VIS) mode for viewing the sample, and grazing incidence reflection (GIR) mode. VIS mode is designed to observe the sample similar to a normal optical objective. To go into VIS mode, a small plane mirror is moved into the optical path which redirects the focus of the 15X reflective objective onto the sample at near-normal incidence. The user can then observe the sample to locate the region of interest for FTIR study. By moving this small mirror out of the way, the user switches to GIR mode and can start the measurement. Please note that the visual image will be distorted in the GIR mode since the light hits the sample at a grazing angle incidence, stretching the image in the incidence direction, and is reflected back across the sample a second time. Photos of the GAO and a figure showing the operating modes are shown in the Fig. 1 and Fig. 2.

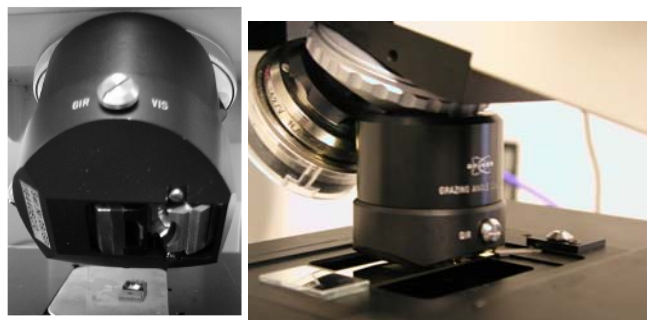


Figure 1: Grazing Angle Objective (left photo from the Bruker Hyperion User Manual, Bruker Optics, right photo as installed on BL1.4.3)

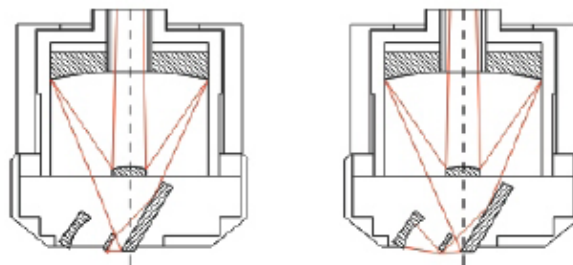


Figure 2: Schematic of the VIS (left) and GIR (right) modes of the GAO (from the Bruker Hyperion User Manual).

We have performed and report here several tests using the GIR objective, including verification of the installation configuration, noise level test, and a mapping test. The test results are summarized in the remaining Figures. Due to the special set up of the optics in the objective, the image at the GIR mode is distorted or stretched in one direction, therefore the spatial resolution is also elongated in the same direction compared to a conventional IR objective. The resulting IR image (Figure 3) is distorted in one direction (aspect ratio = 4:1), and the center is shifted about 320 μm from the original position.

The GIR objective provides a great sensitivity for very thin layers (down to monolayers) of samples. A standard signal to noise test gives 0.06 RMS, which is only slightly worse than the normal result of 0.04 RMS with the synchrotron source (Figure 4, left). And the reflection spectrum of an Al mirror clearly shows the strong AlO_x absorptions from the very thin oxide layer on the Al surface which cannot be observed by a normal incidence objective (Figure 4 right).

We use the resolution target to measure the spatial resolution of the microscope with the GIR objective. The first measurement shown in figure 5 was done with the internal Globar light source. We can clearly resolve the 120 μm lines and the horizontal lines are better resolved than the vertical ones due to the horizontal distortion of the focus spot.

Using the synchrotron light source, we observe a much better spatial resolution as shown in Fig. 6. Imaging an Air Force resolution test target, we can clearly resolve 20 μm lines and spaces, and the IR image quality is significantly better than those taken with the internal light source. 10 μm lines are barely resolved in one direction, but are not resolved in the other direction, demonstrating the effect of the distortion of the focused spot size in the grazing direction. Please also notice the image shift of 320 μm to the left when switched to the GIR mode. Although this spatial resolution is worse than we obtain using the normal incidence objective (which gives a $\sim 2\text{--}5\text{ }\mu\text{m}$ resolution in this spectral range), this result is still better than using the globar source.

Our conclusion is that the GAO is good for measurement of very thin top layers, as small single-molecule thin films, and can be combined with the polarization to measure p-polarized orientations. The increased sensitivity to the uppermost layer comes at an expense of some of our high spatial resolution. We are ready to help the users with this GIR objective and have polarizers available for polarized GIR measurements.

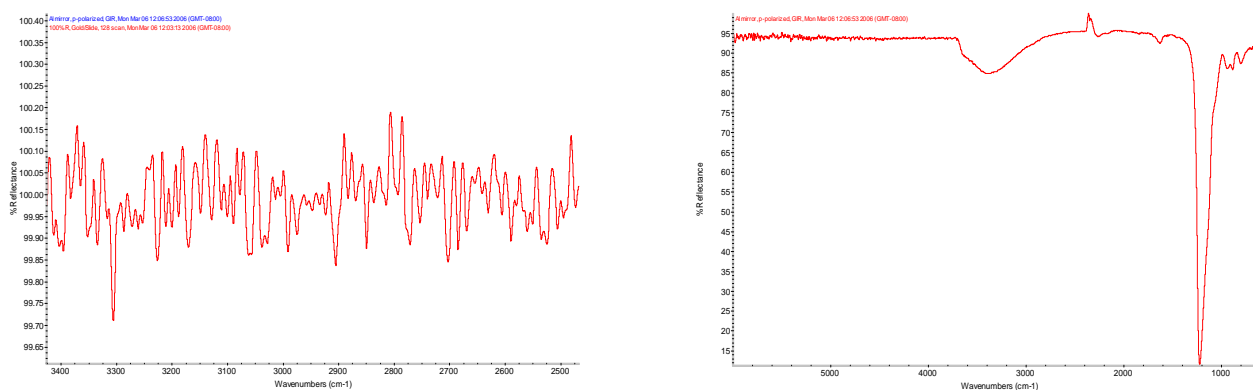


Figure 4 Left: Standard noise test on a gold slide gives a RMS noise value of 0.06; **Right:** The measured grazing incidence reflection spectrum of an Al mirror with p-polarized light. We can clearly see the $\sim 1200\text{ cm}^{-1}$ absorption peak of the naturally formed thin AlO_x layer on the mirror. Data were obtained on March 6, 2006.

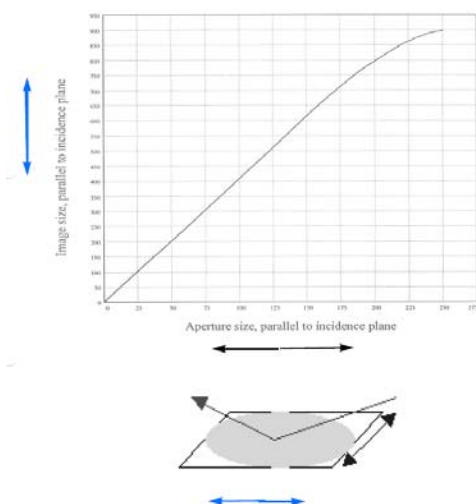


Figure 3: Distorted spot size at the focus of the GIR objective. (from the Bruker Hyperion Manual)

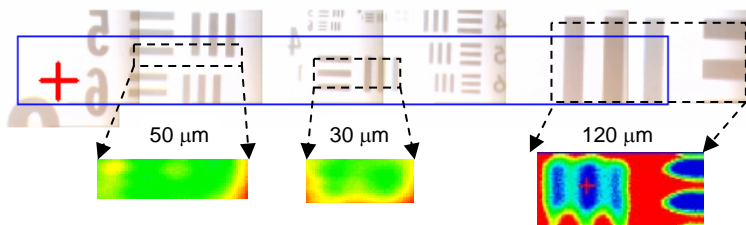


Figure 5: The resolution test with the GAO using internal global light source. The 120 μm features are well resolved. Data were taken on May 1, 2007.

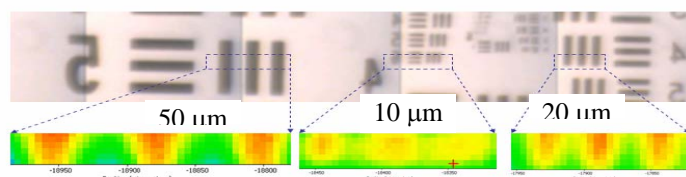


Figure 6: The resolution test with the GAO using synchrotron light source (1000 to 7000 cm^{-1}). The 20 μm and 45 μm features are well resolved while the 10 μm feature is partly resolved. (The visible image is blurred because the focus of the IR light in GIR mode is slightly different from that of the visible light in VIS mode). Data were taken on Oct. 15, 2006.